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Thermally Activated ZnCr Layered Double Hydroxide Based Photocatalysts: Photocatalytic and Antibacterial Efficiency

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Rapid industrial growth over the past few decades has had an immense negative influence on water eco-systems due to the presence of organic and inorganic contaminants in wastewater. Organic dyes, such as Methylene Blue (MB) and Brilliant Cresyl Blue (BCB), frequent wastewater contaminants, raised concerns regarding their toxicity and carcinogenic properties because of their excessive use in various industries and their presence in wastewater. Various wastewater purification processes have been researched, such as adsorption, ion-exchange and heterogeneous photocatalysis. Among them, photocatalytic wastewater purification has the greatest potential due to possible total degradation of pollutants and use of abundant and free solar radiation. Layered double hydroxides (LDHs) and their derived mixed oxides, have shown both, substantial efficiency in the photodegradation of various dyes and significant antibacterial activity. In this study, ZnCr LDH based photocatalysts have been synthesized and the influence of thermal treatment/activation temperature on their photocatalytic and antibacterial behaviour has been researched. ZnCr LDH photocatalyst was synthesized via low supersaturation coprecipitation method, dried at 100°C and thermally treated in air (5 h) at 300, 500, 700 and 900°C (denoted as: ZnCr LDH, ZnCr 300, ZnCr 500, ZnCr 700 and ZnCr 900). Structural and textural characterization, MB and BCB photodegradation efficiency, as well as photo induced antibacterial effect on gram-negative (E. coli) and gram-positive (S. aureus) bacteria was studied. Significant difference in photodegradation efficiency among photocatalysts treated at different temperatures was observed: ZnCr LDH had negligible photocatalytic and antibacterial efficiency, whereas thermally activated samples showed partial or complete degradation of pollutants, depending on the temperature of the thermal treatment. The best photocatalytic and antibacterial behaviour was observed for the photocatalyst treated at the highest temperature, ZnCr 900 (complete MB decomposition, 75% of BCB decomposition and 4 log units reduction of E. coli and S. aureus cell number i.e. 99.99% reduction). Thermal treatment triggered the formation of two photocatalytic active phases, ZnO and $ZnCr_2O_4$, initiating heterojunctions and synergistic effects, responsible for exceptional photocatalytic and antibacterial behaviour. The study showed that thermally treated ZnCr LDH based photocatalysts have great potential for use in wastewater treatment.

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